Technology Opportunity

High Stability Engine Control (HISTEC)

The National Aeronautics and Space Administration (NASA) is sponsoring the design, development, and flight demonstration of an advanced, high-stability integrated engine control system that uses measurement-based real-time estimation of distortion to enhance engine stability.

Potential Commercial Uses

Upon completion of the High Stability Engine Control (HISTEC) flight demonstration, these technologies will be available for both military and commercial engine applications.

Benefits

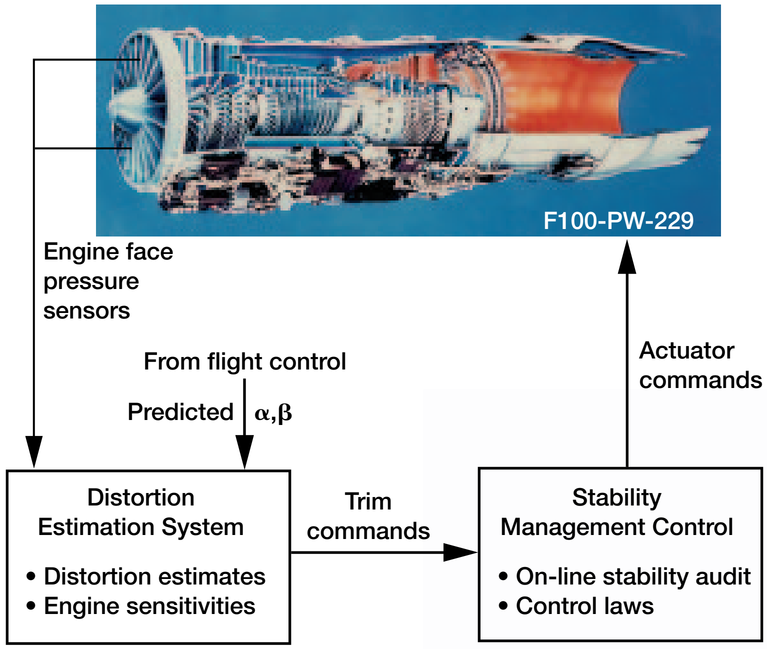
A HISTEC-enabled decrease in design stall margin requirements will significantly increase propulsion system performance and/or reduce weight.

The Technology

Future aircraft turbine engines, both commercial and military, must be able to successfully accommodate expected increased levels of steady-state and dynamic engine-face distortion. Advanced tactical aircraft are likely to use thrust vectoring for enhanced aircraft maneuverability. As a result, the propulsion system will see more extreme aircraft angle-of-attack, α, and sideslip levels, β. These both tend to increase engine-face distortion to greater levels than currently encountered with present-day aircraft. Also, in addition to planar pulse, inlet buzz, and high distortion levels at low flight speed and off-design operation, the mixed-compression inlets needed for the High Speed Civil Transport (HSCT) will likely encounter disturbances similar to those seen by tactical aircraft. These increased levels of distortion usually decrease propulsion systems performance; and more importantly, they reduce the stable flow range of the compressor. Current gas turbine engine design practice is to base fan and compressor stall margin requirements on a worst-case stackup of destabilizing factors. Included in the HISTEC approach are external destabilizing factors such as inlet distortion, as well as internal factors such as large tip clearances. A stability audit is defined and maintained during the development process to account for the effects of each known destabilizing factor. The stability audit totals the worst-case stall margin losses from each of the known factors, adds a margin for engine-to-engine variability, and assures that the fan and compressor have some remaining stall margin. However, this approach results in an increase in design stall margin requirement with a corresponding reduction in performance and/or increase in weight.

The NASA Lewis Research Center is currently pursuing two research approaches that were confirmed as being beneficial by NASA's aircraft engine customers during the NASA-sponsored Advanced Control Concepts study. The far-term approach is to increase the amount of operational stall margin available by actively controlling the onset of stall. This technique is known as active stall control or active stability control. The near-term approach is to increase the stall margin requirement online as engine face pressure distortion is encountered. This approach, distortion tolerant control, allows a reduction in the required design stall margin by an amount on the order of the effect of the distortion.

The distortion tolerant control approach being developed for the HISTEC program includes two major functional elements: a Distortion Estimation System (DES) and Stability Management Control (SMC) (see the figure). The DES is an aircraft-mounted, high-speed processor that estimates the amount and type of distortion present and the effect on the propulsion system of that distortion. It uses a small number of high-response pressure measurements at the engine face and maneuver information from the flight control to calculate, in real time, indicators of the type and extent of distortion. From these indicators, the DES determines the effects of the distortion on the propulsion system. The DES



Distortion tolerant control.

output consists of fan and compressor pressure ratio trim commands that are passed to the SMC. The SMC performs a stability audit online by using the trims from the DES and then accommodates the distortion through the production engine actuators.

Options for Commercialization

Flight demonstration of the HISTEC distortion tolerant control, scheduled for 1997, will significantly reduce the risks involved in developing the HISTEC technologies further and will increase the probability of timely use of the technology in aircraft propulsion systems. HISTEC technologies have potentially broad application to both military and commercial aircraft turbine engines. In addition, the HISTEC program is an example of how NASA and industry can work together to develop advanced control technologies.

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